Art. XII.—*A Physical Description of the Island of Tasmania.*

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The island of Tasmania lies off the south-east extremity of the continent of Australia. It is separated from it by straits about 150 miles wide, and lies between lat. 43° 39′ and 40° 44′ S., and long. 144° 38′ and 148° 24′ E. It is somewhat wedge-shaped, the narrow end being towards the south, as in most islands and continents. Its area is estimated at about 27,000 square miles. Its contour is extremely diversified with numbers of deep indentations, estuaries, and bays, which give it a coast line of very great extent, far superior to any equal area in Australia. It may almost be described as a cluster of high mountains, with a large lake area on its tablelands, and a very extensive drainage or river system.

Tasmania is generally considered as a detached portion of the great Australian Cordillera, or mountain system of the eastern side of the continent, which extends from Wilson's Promontory right up to Cape York, in Torres Straits. Tasmania is nearly in the same line south of this mountain range, and is more or less connected by long islands lying in the same direction and a chain of rocks. But this unity of direction would not of itself prove them to belong to the same mountain system. The two separated portions should belong to the same geological formations, and owe their elevations to the same forces. That this is the case is capable of demonstration.

The great Australian Cordillera may be described as a mountain system composed of certain definite formations, which are more or less well represented in the whole of its course. There is first a granitic axis, on the sides of which altered rocks, schists, slates, and gneissose rocks of uncertain age are seen to rest. Above these are rocks belonging to the Cambrian, Siluro-Cambrian, and Silurian systems, on which are found quartz veins with gold and other minerals. The stratified rocks of this system are always much folded and crusted together so as to give them an almost vertical dip, and lead to great mistakes as to their thickness, unless attention be paid to the way the same strata are repeated in the various folds. Above these are found the Devonian rocks. They lie unconformably upon the Silurian strata, and though in places they have been much disturbed, yet are, as a rule, not so much inclined as the older system. Above these again are found the carboniferous rocks, consisting of lower and marine beds, as they are termed, and the upper or fresh-water series. These beds do not lie comformably upon the Devonian. They are nearly horizontal, but perceptible dips can be observed where they are studied over large areas. These beds are again succeeded by sandstones, called by various names. The two formations do not pass quite conformably from one to another, and the line of division is well marked. It is probable that these beds may be considered as Trias, or Lias, but this is of no moment just now. Their age will depend upon the age ascribed to the coal deposits of which so much has been written. Quite conformably with these are the strata next in succession, which are called the Wianamatta shales, which may be Liassic. Certain sandstones of aërial origin next succeed, whose true position is not yet decided. They lie above the Cretaceous rocks in Queensland, and, possibly, those of N. S. Wales (the Hawkesbury sandstone) may be older. Associated with all these are igneous or metamorphic rocks, called greenstones, or diorites. They are partly volcanic, and partly, no doubt, ash beds, or dykes, but so altered that we can only speculate generally upon their origin. But it is clear that some are the most recent in age, for they have broken through all the older formations, and in some cases altered and disturbed them. They form a very large portion of the rock system of the country. They overspread and completely hide immense tracts of the underlying formations, and sometimes, no doubt, they have broken them up and destroyed them.

Above the sandstones of aërial origin we find nothing of a more recent age until we come to the tertiary drifts, tertiary volcanic rocks, and recent alluvial deposits. These are more or less well represented, but the tertiary volcanic rocks by far the best of the three. Some very large tracts of country are covered with very recent basaltic lavas, doleritic for the most part, but evidently belonging to several periods of deposition. On the southern and extreme northern portions of the chain there is no vestige of any marine formation of later mesozoic or tertiary age. In the middle or central portions of the chain there are a few outliers of secondary formation, but with these exceptions there is an immense blank between the epoch of the carboniferous and geologically recent times.

All these features of the great Cordillera are found in the mountain system of Tasmania. There is the granite axis, then the metamorphic rocks, the Silurian strata, the Devonian, the carboniferous, and probably the Hawkesbury sandstones. After these and amidst them we have an immense development of intrusive greenstones. Then follows a vast blank, until the tertiary basaltic rocks and alluvial drifts are reached. In the whole island there is not the slightest trace of any marine mesozoic rock. On the extreme north side there is a small patch of miocene tertiary, and no doubt there are other such fragments underlying the basaltic rocks on the low lands of the north coast. Such deposits form no exception to its general resemblance to the great Australian Cordillera. On the low-lying flats of those mountains similar miocene or later formations occur, at least on the side opposite to those of Tasmania.

Thus we have in Australia and Tasmania a mountain system composed of the same elements, apparently upheaved under the same conditions, probably belonging to the same epoch, and subject to the same changes afterwards. The differences between the two systems are that the development of greenstones is much more extensive in Tasmania than in any equal area in Australia; and the disturbance and dislocations of all the strata have been more violent and numerous. Thus it is that no single formation can be followed for any great distance in Tasmania. It is broken up and faulted and overlaid by the intrusive rock. This has a most important economic bearing on the mineral productions of the rocks. Coal of fine quality and in thick seams is of frequent occurrence in the carboniferous rocks, but mining has not been very successful hitherto, partly because of the continued dislocations or faulting of the seams. It would appear as if the disturbances which during a long course of ages uplifted the Cordillera, had its period of greatest activity in the southern extremity, which is now represented by the Tasmania mountain system. Before dealing with these various formations separately, it will be necessary to say something about the general direction of the mountain ranges of the island.

As in south-east Australia, the most precipitous portions of the ranges are on the east side. They seem to abut upon the ocean at various places in the whole mountain chain, but this peculiarity becomes more marked towards the south, and most of all in Tasmania. On the east side the mountains confront the ocean with little or no intervening level ground. On the north side there is a considerable area of low-lying ground between the sea and the mountain ranges. This is not a level tract. These are spurs from the elevated plateau which divide the basins of the Tamar, the Mersey, the Forth, the Leven, and other rivers. All these streams empty upon the north side of the island; they have their origin in the elevated tableland, but descending from that have a long course through the comparatively lower land which intervenes between the plateau and the ocean. In some of the valleys or river basins there are patches of tertiary rocks. Some are fresh-water deposits, with abundance of leaves and plant impressions. Some tertiary marine shells have also been found. The dividing ridges between the streams are the usual paleozoic rocks of the Cordillera. As the same rocks are found upon the tableland, there must be a great fault, or a series of them, between these sedimentary rocks and the more elevated plateau This causes the inclined edges of the fossiliferous rocks to abut upon the greenstone masses of the interior.

The plateau or tableland occupies the centre, or perhaps a little to the north of the centre, of the island. In its highest portion it is over 4000 feet above the sea, and the average is not much under that height. It is distinguished by possessing large and deep lakes of fresh water. The Great Lake has a length of thirteen miles, with a maximum width of eight miles, and an average of three to four. It covers an area of 28,000 acres. There are besides Lakes Sorell, Crescent, St. Clair, Arthur, and Echo. They are the sources of all the important rivers in the island. This tableland is for the most part covered with beautiful grass lands, with no important mountains in their vicinity, unless in the case of Lake St. Clair. It is probable that the descent from this plateau is by a series of terraces (notably the Middlesex Plain and Mount Bischoff plateau, averaging 1800 to 2000 feet); and there are also in various parts of the island other tablelands of smaller extent and lower elevation. Thus Lakes Tiberias, Dulverton, and Tombs, on the east side of the island, are similar features. They are seen again in the south-east of New South Wales. The outline of the country around Lakes Bathurst and St. George in that colony is very similar to the lake districts of Tasmania. They are of good elevation, and the geological structure of the rocks is the same.

But though the elevation of the island of Tasmania has resulted in a certain extent of elevated plateaux, yet it has produced in far the greater portion of its extent an uneven surface, composed of broad or narrow mountain ridges or isolated hills. There are three phenomena which are visible here as elewhere:—1. Elevation; 2. Intrusion, or overflowing of volcanic rock; 3. Denudation, or weathering. All these causes may have been in operation until recently, and the last is still going on. The results of endless change, breaking up, and redistribution have produced such alteration in the strata that it is next to impossible to assign any particular appearance to its original cause. Thus a mountain which is now a pinnacle may originally have been a dome, and a sharp or jagged range may have been the edge of a tableland. There are many and various chains of mountains running through the island, some on the edges of the plateaux, and some running actually through their midst. Thus different directions have been traced by Count Strzelecki and others. It must be borne in mind when studying them that they are not certainly axes of elevation, and do not correspond in every respect with the general configuration of the coast line.

Beginning at the north-east extremity of the island—Cape Portland—we find a small ridge about 700 feet high. At a point called the Black Ridge the commencement of the great area of elevation is reached, and the land suddenly rises to above 3000 feet. The chain then takes a south-west direction, and sends off three long branching spurs. The first is the source of the River Boobiala, and terminates in a cluster of conspicuous granite hills, of which the most prominent is Mount Cameron. Next to that is the greenstone of Mount Horror, Mount Barrow, Mount Arthur, and Mount Direction. This spur continues as far as the mouth of the Tamar and ends with Mount Royal. The last spur is the highest part of the mountain system of this side of Tasmania, including the lofty summit Ben Lomond. "It is impossible," says Count Strzelecki,* "to give an adequate

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* *Physical Features of N. S. Wales, &c.*, p. 66.

idea of the outline which these spurs have produced; of those endless sharp-edged ridges, which run in all directions, interbranch, and form, as it were, a network of mountain chains woven intricately together. At times the eye can seize upon their distinct and independent courses, radiating from a common centre, and gradually sloping into flat-bottomed valleys; at times their flanks are erect and perpendicular, imparting to the ridges an appearance of having been rent asunder, and presenting between dark chasms and gorges, from which roaring torrents make their escape." From the northern extremity of what the Count called the "lofty and precipitous battlements" of Ben Lomond, the mountain overhangs profound and tortuous abysses. The central part of the mountain top is a mass of prismatic greenstone columns, 8 or 10 feet in diameter, and their ends projecting over chasms more than 3000 feet in perpendicular depth.

The chain of which Ben Lomond forms the culminating point reaches the sea at St. Patrick's Head. It then takes a south-west course for about sixty miles. It turns westward between Lake Tomb and the Eastern Marshes, and runs north of west to St. Peter's Pass. A spur runs out south at St. Peter's Pass, which separates the Coal River valley from that of the Jordan; and another which separates the Jordan from the Clyde. In this spur, Table Mount (3596 feet) is very conspicuous. It is a slope of tableland which, at a distance, appears like elevated strata of sandstone, though I believe it is an escarpment of greenstone.

The main axis or chain then proceeds northwards, dividing Lake Sorell from Lake Arthur, and extending to Dry's Bluff (4257 feet). The latter is a commanding elevation which forms a conspicuous abutment to the plains of the north coast. Between Dry's Bluff and the Western Bluff the chain has a semi-circular bend, and sends one spur to the north, which terminates at Quamby's Bluff. It also sends others to the south, which divide the lakes from some of the tributaries of the Derwent. At Western Bluff it sends to the north-east a long spur, which divides the valleys of the Mersey and Meander. The range from St. Peter's Pass averages 3500 feet in height, and presents an extremely dark, rugged aspect. Its crests are almost all greenstone. very rocky and barren. To the southward it is still bolder "Its spurs in the vicinity of Lake St. Clair, to the north, north-west, and west, are topped for the most part by more lofty, bare, and cloven summits of quartz rock and syenite, and are divided by darker gullies, the beds of which are furrowed by the torrents" (*Strzelecki*, p. 69). The greenstone and basaltic spur which divides the Forth from the Leven, and that which stretches to Cape Grim on the extreme north-west, are all equally rugged and wild. South of Lake St. Clair there is a spur which divides the valleys of the Gordon and King Rivers, which empty on the west coast. This culminates in the mountain called Frenchman's Cap (4756 feet). The country in this neighbourhood is very little explored, and it is of wild and picturesque character. Another spur makes a semi-circular curve to the eastward, and divides the basins of the Huon and Derwent Rivers, terminating in Mount Wellington (4166 feet). The chain beyond these two spurs bends in a south-easterly direction, sending forth minor spurs, and, with Mounts Adamson (4017 feet), La Perouse (3800 feet), Bathurst Range, and Wilmot Range, barren mountains, standing out conspicuously from various parts, until the axis terminates at South Cape.

The above is only a very general idea of the mountain system of the island, which is more or less picturesque and ruggedly uneven throughout. As the west and south coasts are not settled upon except by a few scattered families of splitters, and as it has been very little explored, much has to be learned about the physical structure and geology of the mountain system of Tasmania. I have not specified all the offshoots from the main chain. Thus the north-west spurs send off two westerly offshoots in succession, one of which divides the Arthur and Pieman Rivers, and another—the Eldon Range (4789 feet)—dividing the Pieman, and its tributary the Murchison, from the King River, which flows into Macquarie Harbour. The south end of this port receives the River Gordon, which drains the north side of another spur from the Wellington Range. The southern side of this spur drains by many tributaries into the Huon. Mount Picton (4340 feet) is one of the highest peaks of this very little known mountain chain.

The general aspect of these mountain ranges is picturesque in the extreme. The summits of the hills are for the most part bare, and studded with romantic crags and precipices. Where the soil is derived from greenstone, and not too precipitous, the forest is extremely dense. The gigantic *Eucalyptus amygdalina* and *E. obliqua* grow thickly with tapering stems of extraordinary height; while the undergrowth is of moss and fern, and shaded by almost impassable thickets of *Pomaderris elliptica, Fagus Cunninghami,* and tree ferns (*Dicksonia antarctica*). The sides of the smaller streams are thus nearly always surrounded by forest. But there is a great difference between the dense vegetation of the comparatively level and open rivers of the plains and those which are supplied from the mountain gullies. The latter are all completely shaded in by a thick growth of forest extending for a long distance on either side. The tablelands are, as already stated, grassy, and free from timber; and in all the country to the south and west, between the densely wooded gullies, the land is open, and clothed with a sedge called button grass (*Gymnoschœnus sphœrocephalus,* Hooker) and *Xyris gracilis, Schizœa bifida,* and many mosses, fungi, and lichens. In all the elevated regions of the western and southern mountain systems the soil is open, poor, and wet. The snow lies upon it for many months, and its humidity and exposed situation render it worthless for settlement.

I will now describe the various geological formations which form the mountain systems of the island.

Granite, syenite, and *porphyritic* granite are well represented on the east coast at George's Bay. It is also found at Mount Bischoff, and occasionally along the Eldon Range, near Ben Lomond, Mount Barrow, and other places. Its connection with other formations is not well made out. As a rule it does not play the most important part in the geology of Tasmania. It does, however, contribute a very important item to the mineral richness, as it is in connection with the granite formation that the remarkable deposits of tin have been found.

Metamorphic Rocks.—It is probable that the base of most of the mountain ranges to the westward consist of metamorphic rocks. They are principally varieties of quartz rock and schist, which appear to alternate and pass into one another. They are especially developed in the country about the Eldon, Arthur, and Frankland Ranges, Frenchman's Cap, Mount Murchison, &c. The mica schist, according to Mr. Charles Gould, consists of quartz and mica in varying proportions. These minerals are sometimes arranged in alternate laminæ, while at others the quartz is aggregated into nodules, which are imbedded in soft micaceous, or occasionally chloritic schists. Those varieties are the most abundant in which the quartz preponderates over the mica, frequently passing into a homogeneous quartz rock. The greater part of these beds possess a very foliated structure, with a lamination in general definite directions. There are no quartz reefs in connection with these deposits. Whatever quartz there is exists in the form of bed rock, and is part of the whole altered strata.

There can be no doubt that these belong to some formerly stratified rocks lying below the Silurian, or even the Cambrian. They are too much altered to contain fossils, if, indeed, they ever did possess them. It is very singular that there are no quartz reefs in connection with them. The beds contain gold in small quantities. Possibly the metamorphic action which changed them from the stratified state has been too partial or limited to segregate thoroughly the gold and quartz into reef deposits. The metamorphism to which they have been subjected is due to—1. The pressure to which they have been subjected when covered by great masses of formations, which have subsequently been nearly all denuded away; 2. Heat accompanying that pressure; 3. Water also much compressed and heated.

Silurian.—At the base of the western half of the Eldon Range, and extending southwards to the Collingwood Valley, certain strata are found a considerable thickness of dark grey mudstones and clay slates with slight admixture of arenaceous rocks, and towards the base calcareous bands and limestones. The dip is not easily ascertained, from the cleavage which affects the upper beds and the contortion of the lower ones. Succeeding these are highly micaceous beds, siliceous grits and clay slates, the latter resting uncomformably upon the metamorphic rocks. On the north shore of the Macquarie Harbour, and the course of the Gordon River for thirty miles from its mouth, and for a short distance of the courses of the King's and Franklin Rivers, and on the line of country between the Eldon Ranges and the West Coast, the usual upper paleozoic and greenstone formations, so common on the east side of the colony, are absent. Their places are taken by several marked divisions of the Silurian rocks, but their exact sequence has not yet been determined. According to Mr. Charles Gould they are chiefly of Silurian, and some of them of Cambrian formation. The most prominent formation consists of fossiliferous limestones, the *entire* thickness of which is not less than 1000 feet, called by Mr. Gould the Gordon limestones.* They are, in some cases, slightly argillaceous and thickly bedded, but ordinarily compact and massive. They are jointed in a variety of directions, and the fissures have been filled with calcareous spars. Irregular fissures or veins of calcareous spars and quartz ramify through the formation. These vary in thickness, and contain galena. These limestones appear again at the great bend of the Gordon River, and at Point Hibbs on the West Coast, at the junction of the Franklin and Gordon. They are then succeeded by sandstones and grits. Below these is a coarse conglomerate consisting of quartz pebbles in a siliceous cement, succeeded by siliceous grits and a variety of sandstones, micaceous sandstones, purple grits, and streaked with quartz veins, apparently passing down into clay, slate, quartzite and micaceous schists. The conglomerate forms the most conspicuous summits of the ranges west of the King's River. Steel grey and yellow clay slates, with fossils, are found in the Mersey district. The organisms include Phacops and Ogygia, Calymene Conocephalites, Orthis Euomphalus.† Messrs. Etheridge, Lesquereux, and Dana have considered the fossils as indicating one of the Lower Silurian formations. Similar formations, but of undetermined age, have been received from Fingal.

The following Lower Silurian fossils have been recorded from Western Tasmania:—Retzia minima, Cyrtodonta auriculata, C. compressa, C. distorta, C. gibbulosa, C. inflata, C. obliquata, C. pinguis, C. reversa.‡ Tellinomya amygdala, T. antipoda, Bellerophon pugnus, Eunema æmula, Helicotoma Milligani, H. pusilla, Holopæa munica, Hormotoma nerinæa, H. usitata, Murchisonia Franklinii, M. mimetica, Raphistoma æterna, Scatites australis, Trochonema, Bigsbyana, Lituites Gouldii, Orthoceras, antilope, P. Murchisoni, P. theca, C. Youngii. There is no Upper Silurian fossil recorded from Tasmania.

Silurian strata, but without fossils, were reported by Mr. Charles Gould (at one time Government geologist) from the north-eastern part of the island, in the county of Dorset. He says it would be impossible to define the limits of these forma-

* The Gordon limestones are most probably the equivalent of the Chudleigh and Midland Plains beds.

†*Proceedings of the Royal Society of Victoria for* 1874, p. 27.

‡ All these are quoted as MS. names of Salter in Bigsby's *Thesaurus Silurieus*, 1868, p. 140.

tions, as they are covered by a drift of sand clay and rounded quartz pebbles. The paleozoic beds are regarded as connected with the Silurian schists of Fingal and the west side of the island. Cambrian rocks are also reported by the same authority along the valley of the Tamar, on low ridges parallel with the ranges, and which have been eroded by the river. Silurian rocks have also been reported from the south side of the island, near Port Cygnet, but I am not aware of the occurrence of any fossils.

Silurian rocks are also stated to occur in the neighbourhood of Mount Bischoff, in the north-west, but are so overlaid by basaltic lava as only to be visible in a few places.*

Devonian.—No fossils peculiar to this formation have been found in Tasmania, though the period is well represented in the Cordillera of New South Wales. As, however, a great many carboniferous fossils are common to the Devonian rocks, it is not at all unlikely that when an accurate survey is made many of the rocks now regarded as carboniferous will prove to belong to a lower horizon.

Upper Paleozoic Carboniferous.—These formations are so very extensively developed in Tasmania that a very long list would be required to name all the localities. As a rule they are exposed in alternate layers of yellow and white sandstones, with shales and thin beds of limestone over which again other sandstones are found. The sandstones are generally firm and hard, but the limestones fall to pieces very readily in some places, and in others these qualities are interchanged. The dip varies, and in many localities there is scarcely any dip at all, but where there has been much faulting from intrusive basalts or greenstones the dip is almost at every angle. No attempt has ever been made to settle geologically the regular sequence of the strata or to determine the horizon to which the various fossils belong. Until a geological map of the east side of the island is drawn after a careful survey it would be premature to say anything decided from the fossil evidence, which is very abundant. Coal is more or less abundant throughout the island. It belongs clearly to the period of the carboniferous fossils. These marine beds, as they are called, are found both above and below the coal. Fossil plants are also found both above and below the marine fossils. It is said that

* "Geology of the Tin Country:" a series of very interesting letters in a local paper, by S. H. Wintle.

the aspect of some of these fossil plants is not paleozoic; and at one time discredit was thrown upon the statement that such plant remains were found under the marine paleozoic fossils. There can be no question whatever that they are found under the marine paleozoic organisms.* It is generally admitted that some of the coal beds are more recent than others, as for instance those of Fingal, but the relative position has not been accurately worked out. As instances of where the fossiliferous strata are found I may mention the valley of the Derwent, New Norfolk, Mount Dromedary, Tasman's Peninsula, the valley of the Tamar, the Mersey, the Don, many places on the East Coast of the island, Oatlands, Fingal, &c.

The following fossils are recorded as from Tasmanian carboniferous deposits:—*Plantæ,* Glossopteris browniana, G. ampla, G. elongata, G. linearis, G. reticulatum (var. browniana ?), Lepidodendron sp ? Phyllotheca hookeri, Alethopteris australis, Thinnfeldia odontopteroides, Sphenopteris alata, Vertebraria australis ? Endogenophyllites wellingtonensis, Zengophyllites elongatus.

Animalia, Favosites ovata, Stenopora informis, S. tasmaniensis, Fenestella plebeia, F. ampla,†E. antiqua (F. densa) (F. fossula), F. gracilis, Orthis michelini, Productus cora, P. murchisonianus, P. pustulosus, P. rugatus, P. scabriculus, P. n.s. close to P. prattianus (Davidson ms.), P. brachythœpus, P. granulosus, P. n. s. (Davidson fide lit), Spirifera clàrkei, S. convoluta, S. rassicostata, S. glabra, S. stokesii, S. strzeleckii, S. tasmaniensis, S. trigonalis, S. vespertilio, S. 12-costatus, S. darwinii, S. duplicostata, Strophomena crenistria, Terebratula ambigua, T. sacculus, Astartilla ? Aviculopecten limæ-formis, A. squamuliferus, A. tasmaniensis Othonota (?) compressa, Pachydomus carinatus, P. globosus, Pterinea macroptera.

It must be admitted that this is a most imperfect list, but the fact is, that Tasmania, though extremely rich in fossils of the upper Paleozoic rocks, has never had its paleontology fairly worked out. It must also be remarked that there are probably two coal floras. One, Oolitic (?),

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* See *Proc. Roy. Soc. Tasm., 1873,* p. 36, where, in a paper on the Mersey Coal Measures, by T. Stephens, Esq., M.A., the occurence of *Glossopteris browniana* in beds *underneath* marine paleozoic fossils is recorded.

† Proretepora, according to De Koninck, who unites four of the species. *See Foss. Pal., N.S.W.,* p. 178.

characterised by Thinnfeldia (Jerusalem); the other, Permian (?), with Glossopteris, &c.

Carbonaceous Sandstone.—In the Oatlands district there is a tableland forming an inclined plane, of which the highest portion is Lake Tiberias. This is about 1460 feet above the sea. The floor of this plain is almost entirely composed of sandstone, which very closely resembles the Hawkesbury rocks. The strata are in two divisions slightly uncomformable to each other. The upper beds are formed of a fine grained sandstone, more or less ferruginous, in thin layers with much false beddings decomposing into a worthless soil from the upper beds. Small seams of coal and carbonaceous bands are met with in the formation, just as they are in a similar deposit in New South Wales. I have no doubt on my own mind, from all I have seen of this district, that the formations are the same. The town of Oatlands is built upon it, and it is well seen round the borders of Lake Dulverton. I am not aware how far this formation extends in Tasmania. I never noticed it except on the Oatlands tableland. It is not fossiliferous. I should say it was of considerable thickness, 200 or 300 feet at least. The line of junction between it and the coal formation is well marked. They are not quite conformable; the coal measures having a slight dip to the south, which brings them to the surface at the north side of York Plains. The junction often shows pebbles of coal and rodled masses of shale and coal measures, marking the denudation previous to the deposition of the sandstone. Both formations are very extensively overlaid by outflows of greenstone; and no doubt were an accurate geological survey to be made many faults would be found as well.

Greenstone.—The rock which bears this name in Tasmania no doubt belongs to several distinct groups of intrusive or metamorphic rocks. It plays such an important part in the geological structure of the island that a detailed examination will be necessary. Its appearance is certainly posterior to the deposition of the carbonaceous sandstone, as it breaks through that rock and overflows it. It forms the capping of nearly all the mountains of the island, from which we gather an important insight into the denudation to which the rocks have been subjected. It is probable that all these deposits of greenstone formed large, unbroken deposits, covering much of the undulating surface of what is now Tasmania. This may have been then a sea-bottom, formed in some places by carboniferous and in others older paleozoic rocks. It did not come from one outlet; in fact, dykes are as commonly distributed as the stone, but the dykes do not always correspond with the mountains. We must, therefore, imagine that the high-peaked summits crowned with this igneous rock mark former points of ejection. They may in some cases, but in the majority these mountains are the jagged, uneven portions of a surface which has been broken by upheaval, volcanic outbursts, earthquakes, and dislocations of various kinds, then cut and scarred by the denudation of wind and rain and sea and flood. The evidence of all this is found in the strata below. They are faulted and wedged out by dykes and intrusive masses of rock in many localities; but there are others where, though the greenstones are in very thick masses above, the strata underneath are very little disturbed. On the extreme west coast, for instance, near Macquarie Harbour, greenstone occurs only rarely, and then it is at great elevations and in the form of capping to the underlying stratified deposits. According to Mr. Chas. Gould, it has the appearance of outliers from the great mass of trappean rocks upon the east; for the regularity and undisturbed condition of the stratified formations below preclude the idea of its having been ejected through. It seems rather to have flowed across from east to west. Boulders of greenstone occur occasionally of great size and in considerable quantities at distances remote from where it exists *in situ.* The junction of the greenstone and underlying rocks is at various elevations, and this is not due to any upheaval, but to the irregularly eroded surface upon which it was deposited. It has been suggested that some of the lakes of the interior have been formerly craters, and Lake St. Clair, with a depth of nearly 600 feet, has been especially cited. What lends a colour to this supposition is that it is surrounded by mountains of greenstone. But, according to Mr. Gould, sandstone crops out from below the greenstone of Mount Olympus, and these sandstones are nearly horizontal, and there are no scoriæ, ashes, or other deposits around the lake.* The more solid portions of ash deposits are often converted into greenstone, and the lighter portions may have easily

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* There is, however, one large deep lake-crater in South Australia named Mount Gambier. The ashes lie there upon perfectly horizontal limestones, which are full of tertiary fossils.

disappeared in the course of time. This is only mentioned to show that the reasons alleged by Mr. Gould are not decisive of the question; but, at the same time, he gives a much more feasible explanation of the lake than a crater origin, which most persons will be disposed to accept. According to him the waters have been penned up in a natural valley by a recent outflow of basalt. It is hardly to be supposed that we should be able to trace the craters which have been formed during the overflow of the greenstones. It may be safely affirmed that the amount of basalt which has been outpoured in recent times in New South Wales or Victoria, or in South and South-east Australia, fully equals, if it does not surpass, the greenstone deposits. The basalts are comparatively very recent, for they are but little, if at all, altered, yet there does not remain a single crater in all South-east Australia, and in the colony of Victoria they are very few. It is only as we go westward to where the evidence of volcanic action dies out that we find undoubted ash craters with tufaceous deposits.

In all probability the greenstones of Tasmania are ordinary basaltic lavas, alternated by metamorphic action, or chemical change, in which time and weathering were probably the principal agents. After the researches of Mr. J. A. Phillips on the "greenstones" of Cornwall, we cannot hesitate to pronounce on those of the island. In Cornwall they are proved to be lava, closely resembling those of modern date. They are, in fact, dolerites, in which the augite has gradually been transformed into hornblende and viridite*, while the felspar merges into a granular mass. The titanic iron is gradually replaced by a greyish-white product of alteration, and a little epidote subsequently appears. The quartz, when found in these, is a result of aggregation. No attempt has been made to my knowledge to determine the character of the Tasmanian greenstones. They are described thus by Count Strzelecki (*Loc. Cit.*, p. 101) :—

Diabase.—Brongniart; Diorite, Haüy.—The varieties of this kind of rock are uniformly composed of felspar and hornblende, in the state of grains or small crystals, in

* Viridite.—This term refers to microscopic petrography, and is used to express green or transparent substances visible in thin sections under the microscope, forming scaly or fibrous aggregations, resulting from decomposition of augite, hornblende, or olivine. The composition varies, but consists chiefly of silicates of monoxyde of iron and magnesia.

proportions somewhat different, but in which the hornblende predominates. They vary, also, in their structure, being—1. slaty; 2. prismatic; 3. amorphous. 1. Slaty greenstones or schistoid Diabase. Colour, in recent fracture between leek and pistachio green, decomposing on the external surface to a dull reddish brown. Internal surface has a waxy lustre. The imbedded crystals of hornblende are generally brilliant. Its structure is schistose, but the layers are never parallel, and are running from a thickness of two or three inches to a wedge-like termination. For the most part its seams present a lenticular form resembling convex lenses, thus (says the Count) beautifully illustrating the successive overflowings of the incandescent matter. It does not adhere to the tongue, and exhales an argillaceous odour. The streak varies. Its powder is a brownish yellow colour. Structure, compact and hard. The Count adds that the localities which supply the most important facts bearing on its geological relation are between Launceston and Mount Direction, Mount Direction and George Town, Stony Head, Cape Portland and St. Patrick's Head, Break-o'-Day River and the Tyne, Ben Lomond, Ben Nevis, Port Sorell, Day's Bluff, Lake Arthur, Lake Sorell, the Great Lake, Lake St. Clair, Western Bluff, Mount Cradle, and the source of the Nive, and Mount Cameron West. He says, also, that this variety of greenstone occurs at various heights, capping all the prominent elevations of the interior of the island. It is invariably and intimately associated with porphyries, argillaceous schist, mica, slate, syenite, granite, siliceous slate, and limestone. When it is isolated from the prismatic or amorphous greenstone, its seams are horizontal. When, however, these varieties are in contact with it, the seams are vertical, broken, and distorted.

The examination of the great area which this schistose greenstone covers in Van Diemen's Land, leads to the discovery of sources from which it overflowed the island. The principal sites appear to have existed in the vicinity of Cape Portland, between Mount Barrow and Mount Arthur, on the north side of Ben Lomond, on Mount St. Patrick, at Port Sorell, on Mount Cradle, Mount Cameron West, and at the source of the Nive. In all these places the schistose greenstone is associated with porphyry. This association strongly led the Count to believe that the greenstone flowed along the pre-existing slope of the consolidated porphyry.

2. *Prismatic Greenstone.*—This rock does not differ from the preceding, except that its structure is prismatic, the prisms having from three to seven sides. It is principally seen on Ben Lomond, where prismatic columns are found from three to eight feet in diameter, and sometimes one hundred feet long. There have been no observations on this rock in Tasmania. Similar rocks in New South Wales, Victoria, and Queensland have been microscopically examined. Mr. Allport, of Birmingham, says of that of Gympie (Queensland) that it is a diorite, containing hornblende triclinic felspar, orthoclase, biotite, and pyrites. There was also a little chlorite and quartz filling up the spaces between the crystals. Many of the crystals were imperfectly crystallised, but the rock was not much altered.

Some of the diorites of Victoria have formed the subject of a very elaborate paper by Mr. A. W. Howitt, F.G.S., read recently before the Royal Society of Victoria. He says that dykes of diorite are of very frequent occurrence at the Swift's Creek diggings. They are from one to five feet wide, and have not any common direction of strike. They are sometimes visibly crystalline, and composed of white plagioclase and dark green hornblende. A microscopic examination shows quartz, viridite, apatite, and combinations of iron.

There can be no doubt that these rocky masses and dykes of diorite wherever they are found are portions of one continued period of volcanic disturbance to which this part of the globe was subject during mesozoic times. In New South Wales and Queensland many of the igneous rocks are intercalated with the carbonaceous deposits. I am not aware that this has been noticed in Tasmania, though the examinations have been very imperfect. But one thing seems to be very certain, and that is that the bulk of the Tasmanian diorites flowed out after the coal period, and probably at the end of the mesozoic epoch alluded to. In a paper on the Hawkesbury sandstone, read before the Royal Society, New South Wales, May, 1882, I have stated my reasons for believing this formation to be an aërial one. It may, therefore, have accumulated round the igneous rocks, and is not in reality under them, though it has that appearance. This may be the explanation of the greenstone cappings or outliers.

Has the island been submerged since the mesozoic period? On the north side it has—that is, the low-lying portion of the north coast, far away from the table-land. But with regard to the rest we may say that there is an extreme probability that it has not. It is true that we have evidence of immense denudation in the greenstone, and that in north-east Australia we have an extensive development of secondary rocks and formations ranging from the oolitic to the cretaceous, but these formations seem to be confined to the north-east side of the continent. It is hardly likely that any formations could have existed here without leaving any trace, not merely of fossils, but of other changes.

It must be admitted that this negative evidence is not conclusive. It receives a little more confirmation from the extensive outbursts of basaltic lava which are found throughout the island. These lava-flows lie either upon the carbonaceous deposits, or upon drifts, or directly upon the greenstone. They are of various ages, but probably not earlier than the tertiary period. If there be yet any hope of finding secondary formations in the island it will be underneath these basalts. The tertiary lava flowing over them would thus preserve them from wearing. No such deposits have yet been found, as far as marine fossils are concerned, but plant remains are not uncommon. This shows clearly that the land was above the sea at the time of the outpouring of the basalts.

These modern volcanic rocks are nearly of similar character throughout. They are black or dark blue vesicular basalts, similar to what are found in New South Wales and Victoria. They are almost as extensively distributed as the greenstones, and are found at every altitude. They form densely wooded hills on the south-east side of the island, and are more or less visible in the east and north coast, on the table land, and through the island, such as near Oatlands, Lake Arthur, Lake St. Clair, Launceston, Table Cape, Cape Grimm, &c., &c. Near Brighton a very fine section of columnal basalt is visible. The general character of the rock is doleritic. The only specimen I ever had an opportunity of examining appeared to me to show a felspathic dolerite, with triclinic felspar, augite, magnetite, and either olivine or pseudomorphs, after olivine. The augite is in small brown crystals. Mr. Ulrich, of Victoria, made sections of the basalt at Table Cape, and found the composition to be very similar to some of the recent basalts in Victoria. It was a felspar, with very little augite. Vitreous quartz, magnetite, and olivine basalt from Breadalbane, where there are plant remains and leaf deposits, contained well-developed crystals of augite. No conclusion as to the age of the rocks can be formed, except that they are tertiary. Of that we may be certain—first, because at Table Cape they overlie marine tertiary beds of miocene age; secondly, because at Breadalbane some beds overflow plant remains, which are tertiary, and identified by some of the plants with pliocene vegetable remains in Victoria and New South Wales. These two outbursts must be of different age, because the Table Cape beds have flowed over the bottom of the sea, which has since been upheaved; but those of Breadalbane have flowed later, over dry land.

No crater remains to show the points of ejection. It does not take long to destroy such records, but we may conclude at least that there has been no volcanic activity in very recent times in Tasmania, such as we know existed in Western Victoria or the south-eastern district of South Australia, where several craters are still visible. The more westerly they are situated the more recent in character they become. The one most to the westward is quite modern.

The tertiary marine beds at Table Cape form a small patch of fossiliferous strata which owe their preservation entirely to the capping of basaltic lava. Probably similar patches are to be found under the basalt on the north coast. At Breadalbane, miocene fossils are sometimes found in wells. The formation is part of the great tertiary deposits of Southern Australia, which extends with occasional interruption over 20° of latitude and 10° of longitude. It consists at Table Cape of bands of limestone, marl, and clays, the latter often ferruginous and containing gravel, as if the beds had been derived from decomposing traps. The fossils identified are:—Murex eyrei, Fusus meredithæ, F. roblini, F. johnstonii, F. tateana, F. transenna, Triton abbotti, T. minimum, Buccinum fragile, Trophon fragile, Cominella lyræcostata, C. cancellata, Thala marginata, Nassa marginata, Terebra additoides, T. simplex, Cassis sufflatus, Cassidaria reticulospira, Syrnola bifasciata, Actæon scrobiculatus, Columbella oxleyi, C. caniozoica, Pleurotoma johnstonii, P. paracantha, P. sandleroides, P. pullulascens, Ancillaria mucronata, Voluta hannafordii, V. anticingulata, V. antiscalaris; V. weldii, V. macroptera, V. granatina, V. maccoyi, Marginella wentworthi, M. strombiformis, M. octoplicata, C. platyryncha, C. gastroplax, C. eximia, C. archeri, Trivia mimina, T. avellanoides, Daphrella columbelloides, D. tenuisculpta, D. gracillima, Mangelia gracillina, N. wintlei, N. vixumbilicata, N. polita, Turbonilla lyræcostata, T. pagoda, Eulima danæ, Cerithiopsis johnstonii, Turritella tasmanica, T. sturtii, T. warburtonii, Vermetus conohelix, Tenagodus occlusus, Rissoa stevensiana, Rissoina varicifera, R. tateana, R. johnstonii, Turbo etheridgei, Imperator imperialis, Trochus josephi, Thalotia alternata, Gibbula crassigranosa, G. clarkei, G. æquisulcata, Astralium flindersii, A. ornatissimum, Margarita Keckwickii, Zizyphinus blaxlandi, Delphinula tetragonostoma, L. tasmanica, L. discoidea, L. lamellosa, Solarium gibbuloides, Fissurella concatenata, Emarginula transenna, Crepidula lævis, Trochita turbinata, Cylichna arachis, Humphreya arachis, Dentalina kicksii, D. lacteum, Terebratulina davidsoni, Waldemia gerybeldiana, W. macropora, W. gambierensis, Terebratella compta, Rhynconella lucida, Ostrea sp., Lima bassi, L. sp., Plicatula, Spondylus gaderopoides (?), Cucullea corioensis, D. cainozoica, Arca sp., Pectunculus laticostatus, Limopsis belcheri, L. aurita, Nucula tumida Leda crebricostata, Chama lamellifera, Venus allporti, V. propinqua, V. cainozoica, Cardita gracilicostata, Cardium sp., Crassatella oblonga, C. aphrodina, Tellina cainozoica, Solecurtus legrandi, Lyonsia agnewi, Myodon, Trigonia acuticostata, T. semiundulata, Vulsella sp. Balanus, Micraster brevistella, Lovenia forbesi, Leiocidaris, Heliastrea ————, Thamnastrea sera, Balanophyllia australiensis, Dendrophyllia epithecata, Trochoseris woodsi, Conotrochus maccoyi, Sphenotrochus excisus, S. deltoideus, Montlivaltia discus, Placotrochus elongatus, Conocyathus viola, Dendrophyllia duncani, Flabellum duncani, F. victoriæ, F. gambierensis, Cellepora gambierensis, C. spongiosa, C. nummularia, C. hemispherica, Spiroporina typica, Retepora sp.

Tertiary Plant Beds.—In Mr. Chas. Gould's report of the exploration of Macquarie Harbour, he gives the following account of a tertiary formation existing there. He says that on the north side of Macquarie Harbour and for some miles up the Gordon River there are cliffs, at many points, 70 or 80 feet in height, consisting of coarse sand, rock and shales, largely impressed with leaves of existing plants, and containing occasional thin seams of lignite, which have caused reports of coal there. Raised beaches (?) of loose quartz-pebbles surmount them, and form elevated pleateaux of marsh land on the southern as well as on the northern side of the harbour. I am not aware of any further attempts to explore these tertiary beds. Mr. Gould is right in supposing the plant impressions to be those of existing species. The formation is probably a pliocene one, and the rolled pebbles above suggest a drift like that in which the alluvial deposits of gold are found in Victoria. The lignite is, however, not usual.

Other plant beds of tertiary age have been ably described by Mr. R. M. Johnston. In the immediate vicinity of Launceston and scattered over the westward plains there are accumulations of water-worn gravel, one to three feet thick, arranged in horizontal layers, and associated with clays and tufa more or less laminated. The most extensively exposed bed is on a railway cutting between Perth and Longford. This is on a tableland about 115 feet above the present channel of the South Esk, at Longford, and 630 feet above the level of the sea. These beds are principally composed of siliceous pebbles and gritty concretions, all more or less waterworn and cemented together. Opalized wood is scattered throughout the whole of the gravelly accumulations. With them are also associated pebbles of limestone, derived from the carboniferous beds, and containing casts of fossils characteristic of that formation. In the laminated clays are found beds of lignite intercalated with beds of fine blue clay, containing remains of water plants, fragments of branches, twigs, and leaves, and occasional *Unio* shells. In a cutting beyond Breadalbane a section of tufaceous rock is exposed, in which there are numerous fragments of branches and trunks of trees disposed horizontally. These are principally composed of lime.

Mr. Johnston divides all the beds into the upper, middle, and lower, which he thus characterises :—Lower beds : Composed of series of beds of blue and white clays, occasionally inter-laminated with thin bands of tenacious clay, containing leaves, for the most part exogencus, and a considerable portion coniferous. Myrtaceous forms do not seem to predominate, but there are leaves very similar to our finely pinnate acacias. In an exposed cliff section on the North Esk, Mr. Johnston states that he found fragments of Banksia and Eucalyptus, which, of course, would approximate the deposits to the living flora. The middle beds are chiefly composed of beds of clay and sand, with leaf impressions. The upper beds are represented by the low rounded hills and terraces flanking the present course of the River Tamar. They are composed of alternate beds of conglomerates, breccias, and gravels, and the detritus of the lower strata. At a bend in the River Tamar, called Stevenson's Bend, there is a very rich deposit of leaf impressions in the banks; and at Breadalbane Mr. Johnston gives the following section:—Superficial soil, 2 to 3 feet; basalt, 50 to 60 feet; conglomerate of waterworn fragments of basalt, 3 to 4 feet; white arenaceous clays, 20 to 30 feet; lignite, with embedded trunks and branches of pine and other trees, 3 feet. White and grey arenaceous sands of unknown depth.

From this it would appear that the plant beds denote a flora which existed at the time of some of the volcanic outbursts, but Mr. Johnston is of opinion that the lowest beds rest upon a very old basaltic stratum. My own impression is that the lowest sands are contemporaneous with the older pliocene deposits of Victoria (?) and South Australia, where they are manifested in a similar manner. They rest upon older basalts which cover marine miocene formations, and these may be the basalts which overlie the Table Cape deposits, and which were deposited on the bottom of the miocene sea.

Close to Hobart, on the south side of the island, tertiary plant remains, with land shells, have been found. They occur in a deposit of travertin in Geilston Bay, on the Derwent River, on the opposite side to Hobart. Abundant leaf impressions, with fossil leaves and wood, have been found in this travertin, with two species of Helix, a Vitrina and a Bulimus. The plant beds have been displaced by a basaltic dyke. The displacement of the stratified beds by the dyke has caused many fissures and cavities, in which the bones of existing animals are lying in abundance. The seeds found in the travertin beds show the deposit to be contemporaneous with the pliocene drifts of Victoria.

I have now dealt with all the evidence that is known in Tasmania as to physical condition of the island in former geological periods. The question remains to be asked whether we have any evidence that it was formerly united to the Australian continent? There is no geological evidence. It forms a part of the continent geologically, and the space between the two is bridged over by islands. They are of the lowest formations known in Tasmania, covered, in some cases, with miocene and pliocene marine deposits. In the tertiary era, therefore, it is extremely probable that the sea rolled between them, even to a larger extent than it does now. The evidence is in favour of Tasmania, like South-east Australia, being dry land during the latter part of the Mesozoic period. We have nothing to show us that the lands were connected then, except the present similarity of the fauna and flora, which I hope to deal with at some future time. Let it be well borne in mind, however, that the similarity or identity of a fauna and flora is not a proof that the lands were formerly continuous. This similarity may arise from many independent causes, which I need not specify.

Art. XIII.—*An Improved Grab Crane.*

By C. W. Maclean.

[Read 10th August, 1882.]

The system of dredging by means of a bucket formed of two hinged scoops or forks, known as grabs or clam-shells, having mechanical contrivances for opening and closing by chains worked by a derrick crane in such a manner as to grapple and lift spoil, has long been known and used by engineers on the Continent, India, Great Britain, America, and other parts of the world.

Having observed several defects in the working of the usual forms of grab cranes, I designed a new grab and crane which effectually overcomes these defects, and which I will now proceed to describe, prefacing the description by an extract from my British patent specification:—

"My improvements in grabs relate to the contrivances through which the grappling portion receives its necessary motions of opening, closing, hoisting, and lowering. The improvements in the contrivances used for working the same consist, first, in the substitution of a counterbalance barrel, supported and running in racks at the back of the crane, for the ordinary counterbalance weight, and in so arranging such counterbalance barrel that it assists instead of retards the engine in all the operations of working the grab;